What Is A Level 5 Organization?

Lessons from 10 years of process improvement experiences at CSC

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November 29, 2001

What is 'Process Maturity'?

- Process Maturity represents the degree to which practices in an organization comply with a given benchmark.
- Determined by comparing practices of an organization with the established Benchmark
  - ISO Registration audits, CMM SCE, SA CMM SCE…
  - Evaluations typically assess both the written processes and evidence that processes are used.
  - Evaluations generally do not review product (e.g. cost, quality, timeliness,…)
- It is assumed that higher levels of benchmark compliance will lead to improved performance
  - More mature organization will perform 'better' than a less mature organization.

Expected Value of a Higher Maturity*

- Decreased risk
  - (Compared to less mature organization) of carrying out a project successfully
- Higher level of consistency
  - For multiple tasks/projects being performed
- Increased visibility
  - Of project schedules, cost, risks
- Realistic planning/estimating
  - Increased likelihood of meeting commitment
- Lower defect rates
  - In delivered products

* http://www.sei.cmu.edu/cmm/cmm.articles.html

Why Select Mature Organization?
(What is expected by client)

- Faster start-up
  - Established accepted practices in place
  - Infrastructure is well-defined- ready
    - QA, CM, PEO
  - Established approach to 'improvement'/ change
- Known performance record
  - Measures exist which show performance history
  - Can see productivity, cost of infrastructure
- 'Corporate' Commitment to process/ quality
  - Demonstrated allocation of resources
  - Part of the corporate culture
- Visibility of established practices to be applied
  - 'You get what you see'
  - Established approach to process and process change
- Higher probability of meeting commitments
- Continuous improvement as measured by needs of the client (e.g. cost, quality)

Observed performance of High Maturity Organizations

*** What are the organization attributes?**
(What does a 'Level 5' look like?)

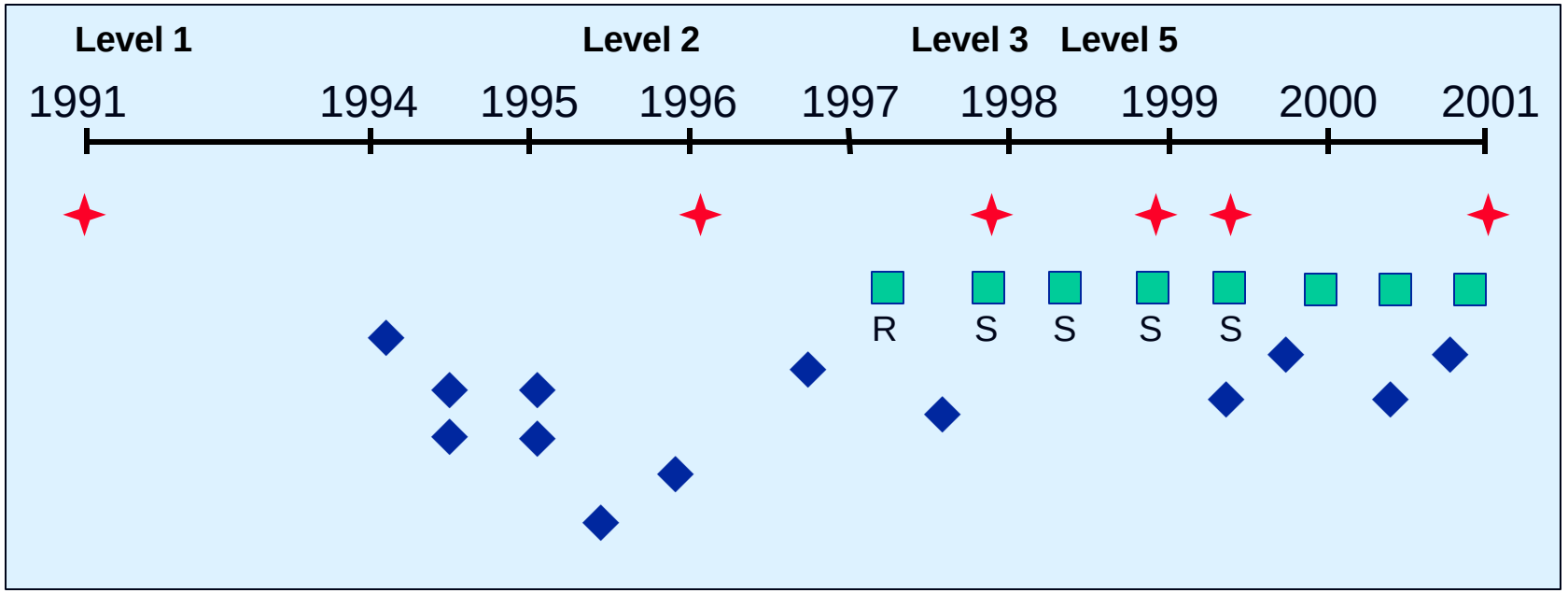
***What are the performance attributes?**
(Does a 'Level 5' produce better software?)

Basis for the Observations

- CSC Flight Dynamics Department (and SEL)
  - Detailed data collected for over 15 years (1980's and 90's)
    - Process and product data archived and analyzed
    - Detailed information for nearly 90 projects
  - Winner of the First SEI Process Achievement Award (1994)
- SEAS Center
  - Data tracked from 1991 (rated as a Level 1 organization) through November 1998 (rated as Level 5 by independent SCE team) and to the present
  - Observations captured from Level 1 through Level 5
  - Data from over 25 additional (to flight dynamics) projects archived and hundreds of artifacts generated to capture lessons and experiences.
  - Civil Group performance assessments
  - Internal assessments in preparation for CMM and SA-CMM
  - Independent SCEs
    - Observations captured from 5 major programs- ranging from level 1 through 4
- ISO appraisals and preparation for 6 major programs in CIV
- Additional Civil Group and Defense Group organizations
  - Performance analysis for Level 2-3-4-5 organizations in CSC*
  - Assessment Information (ISO, CMM, SA CMM, IPA) archived and reviewed (Results ranging from

**Studies by Paul Adler (USC)'Discipline of Process: The Transformation of Software Development' (Draft 10/17/01)*

SEAS Center Benchmarking History



- External SCE
- ISO 9001 registration audit (R), surveillance audits (S)
- Software process self assessments (SPA) and (IPPA)

Quantitative Models Have Been Established

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- There are quantitative models of software
  - Cost models
  - Defect models
  - Effort models
  - Performance models
- Analytical models have been derived from historical data
  - Process performance models allow ‘what-if’
  - Product models are known and used for planning
  - Ability to estimate resources/end points based on history
- Measurement program is underlying theme for enhancing knowledge and models
  - Measurement has generated ‘profile’ of process and product
- Artifacts exist where specific models are available
  - Archive and access to models provided (e.g. Profile and Models documents/reports exist)

Measurement Is Used to "Engineer" S/W

1a

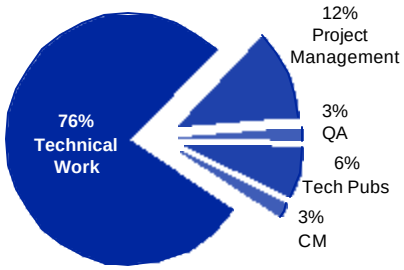
- Established program for applying measurement exists
  - Results are readily identifiable
  - Personnel understand 'why' measurement (models, managing,guiding change)
  - Measurement produces engineering models
- Level of measurement suits the environment
  - GQM
  - Limitations of measurement are realized
    - Statistical analysis tempered w/ subjective insight
- Analysis results are routinely reported

Models Exist for Process and Product

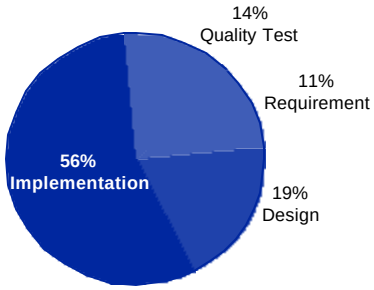
Engineering Models of Processes

NASA Programs Software Product Characteristics
(Cost Distribution)

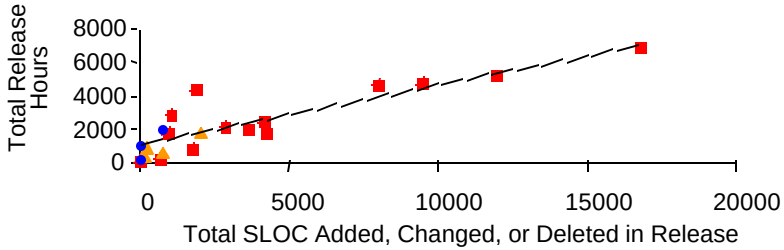
By Support Activity



By Development Activity



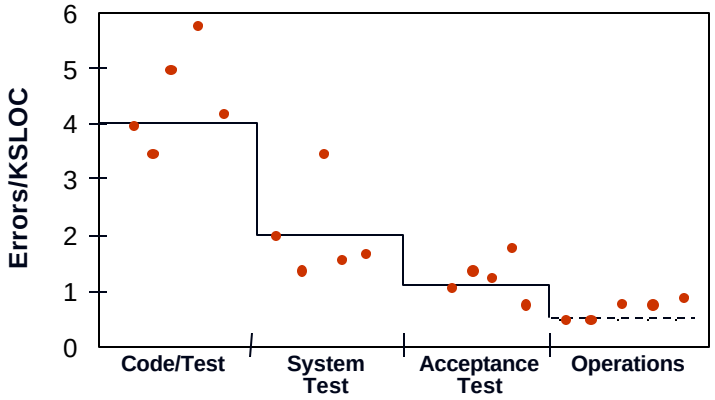
Size of Change Vs. Effort in Maintenance



Effort = (0.36 * SLOC) + 1040 R**2 = .75

- Enhancement Releases
- Mixed Releases
- Error Correction Releases
- Linear (Enhancement Releases)

Example of Model Building in SEAS

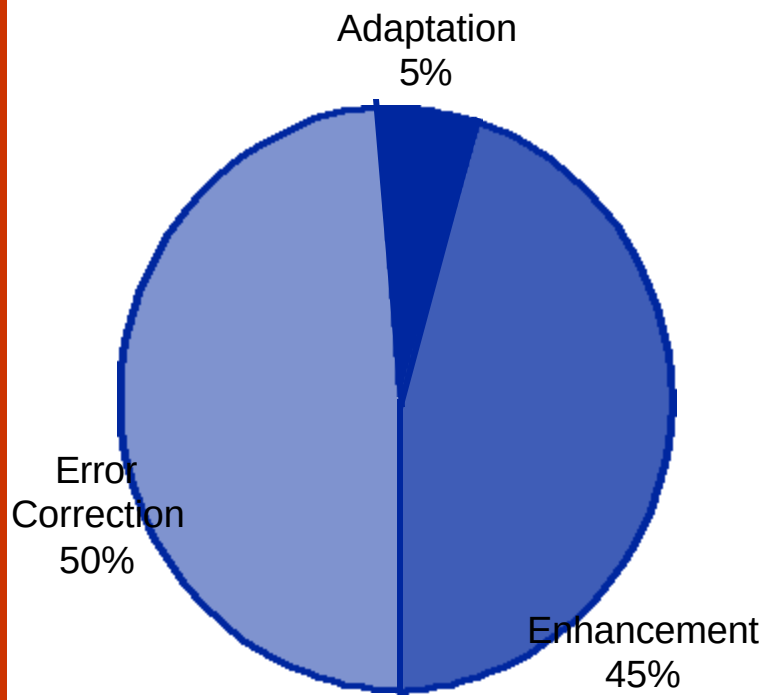


SEAS environment expects to half error rate in each subsequent phase

**Based on 5 similar projects in SEL*

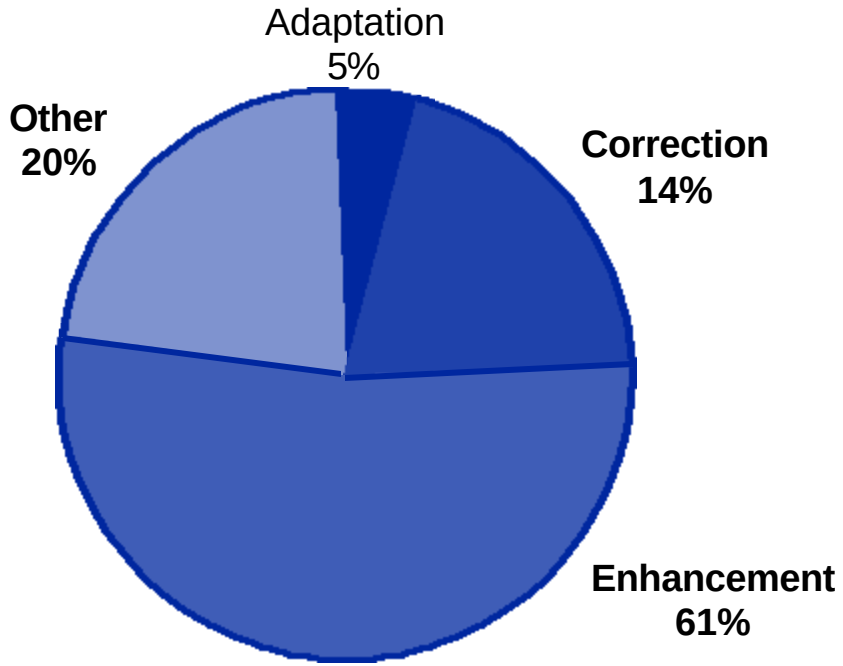
Model of maintenance activities

Maintenance by Type of Activity
(Distribution of Number of Changes)



Bugs comprise 50% of needed fixes

Effort Distribution by Type of Change



Fixing bugs requires only 14% of the cost

(Senior) Management Reinforces Value of Process

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- Process is routinely addressed at management reviews
  - Management has culture of process
- Senior management participates in process activity (planning, improvement, evaluations,…)
  - Establishes use/adoption guidance for all managers
  - Actively reviews program and sets goals
- Aggressive program for process is established
  - Incentive programs
  - Resource allocation
  - Limited ‘waivers’ approved (e.g. waiver from improvement/ assessment participation)

Established Processes Reflect Accumulated Experience- Rather Than Benchmark Detail

3

- **Set of established processes exist, known, applied**
- **No emphasis on specifics of benchmarking- (CMM, ISO,..)**
  - But staff is comfortable with the process assets
  - Staff focus is on 'process' not CMM
- **Awareness of why process related activities are performed** (why QA, why measures, why change,…)
- **Personnel view process as value as opposed to overhead**
  - 'Every person we interviewed was extremely comfortable in talking process- they understood the concepts' (SCE debriefing 1/01)

    "…in many ways, the SEAS organization goes beyond CMM in improving process, they have pushed beyond Level 5 …."
    (Paul Byrnes, SCE team lead- 11/'98)
  - **Infrastructure for support allocated to process**
  - Training is integral part of the process culture
  - Very identifiable roles in assurance, process, and control
  - There exist specific lists of controlled processes and products

Appropriate Resources Allocated to Process

4

- **Support staff designated in organizational structure**
  - Identifiable roles in assurance, process, and control(CM)
  - Staff allocated- independent from project overhead
  - Training is integral part of the process culture
- **Staffing of support services reflects level of perceived value**
  - some immature organizations do not allocate appropriate staff to support functions.
- **Specific level of resource established**:
  - Assurance ~1.75% of total organizational size
  - Process ~1.25%

Program Size	0-20% Software	20-40% Software	40% Up
70 - 150 FTEs	1.5 FTEs*	2.0	2.5
150 - 400	2.0 -2.5	2.5 - 4.0	3.0 - 4.5
400 - 900	3.0 - 4.0	3.5 - 4.5	4.5 - 6.0
900 - 1700	3.0 - 5.0 *Process only(not QA)	4.0 - 6.0	5.0 - 7.0

Multiple Benchmarks Used to Guide Change

5

- Adoption of CMM, ISO, QIP, TQM simultaneously is common
- Realization that single benchmarks may address limited functions
  - CMM focus is software only
  - TQM, ISO, QIP, Bootstrap,..often included to enhance
  - Program driven by concepts as opposed to benchmark detail
- Benchmarks are viewed as tools as opposed to goals
  - Improvement program captures goals of benchmark- not detail.
  - PIP not characterized by '…we are a 1 and goal is 5..'
- Organizational-wide participation in improvement activities is apparent
  - As opposed to software only

Aggressive Deployment Program Exists

6

- Emphasis is on infusion of practices, as opposed to developing new/ modified practices
- Experts assigned to support project adoption- not to enforce compliance
- Training program tailored to complement infusion of process

Activity	4-Year Cost	1995-1996	1997-1998
Develop/Maintain Processes (write/update)	6 Staff-years (SY)	35-40%	15-20%
Deploy/Training/Awareness	10 SY	10-15%	40-45%
Infrastructure (data base, libraries, distribution)	2 SY	5-10%	3-5%
Process Improvement (planning, studies, experiments, analyzing)	8 SY	12-15%	25-30%
Assessment Preparation (SCE, ISO)	3 SY	20-25%	5% - 8%
Reporting/Reviews	1 SY	3%	3%

Issues and Problems Addressed Within Scope of Processes

7

- Diversions and issues happen- mature organizations expect them
  - Issues not treated as ‘show-stoppers’, but as incidents that must be addressed with process
- Project staff know ‘what to do next’ and ‘what is required to complete a product or phase’
  - Approach to adjusting schedule, cost, priorities exists
  - Red-flag reviews are part of the process
- Established processes enable raising issues to appropriate level
- Steps for capitalizing on experiences apparent
  - Lessons, Causal analysis, team analysis

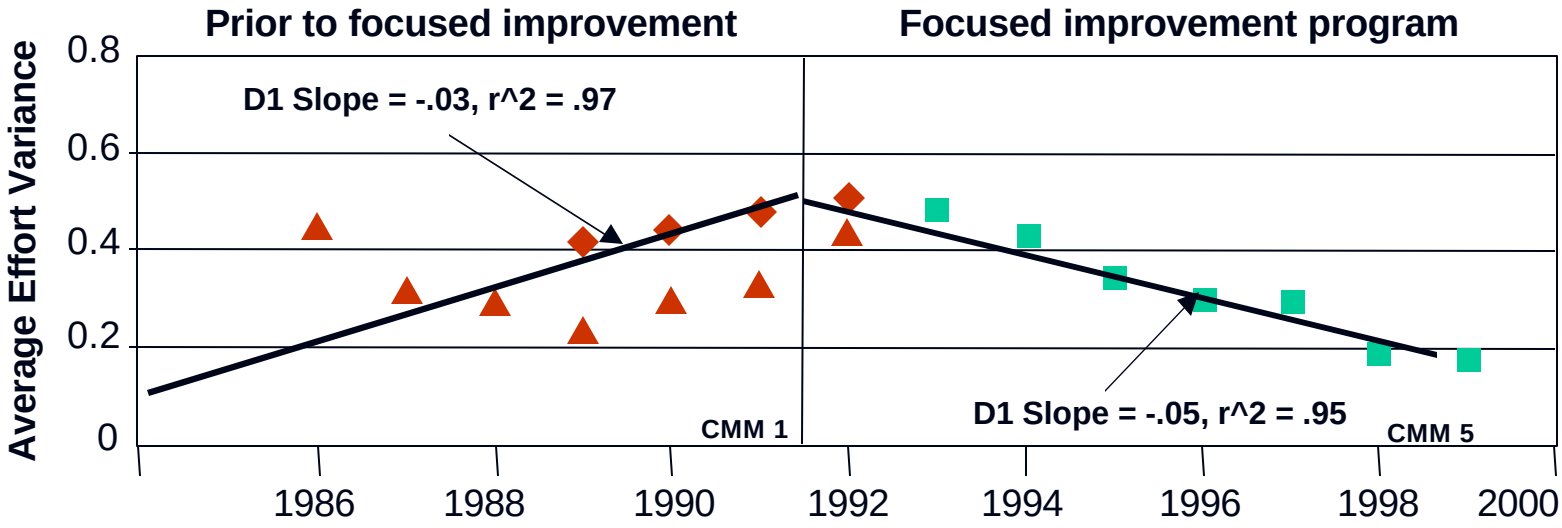
Performance Attributes of a Mature Organization

- What performance should we expect from a mature organization?
- What evidence exists within Civil Group to indicate any impact of higher maturity ratings?

Lower Risk in Meeting Project Commitments

1

- Historical information exists as basis for estimating, planning
  - Ability to estimate end points
  - Ability to respond to change
  - Have models of performance enables ‘what if’
- SEAS cut ‘Red-Flag’ projects by 3 to 1 in 5 years.
  - Projects outside 10% limit of cost/schedule:
    - 17% in 1995 vs. 5.5% in 2000
- Average effort variance improved by factor of 2 in 5 years (in 1 environment)

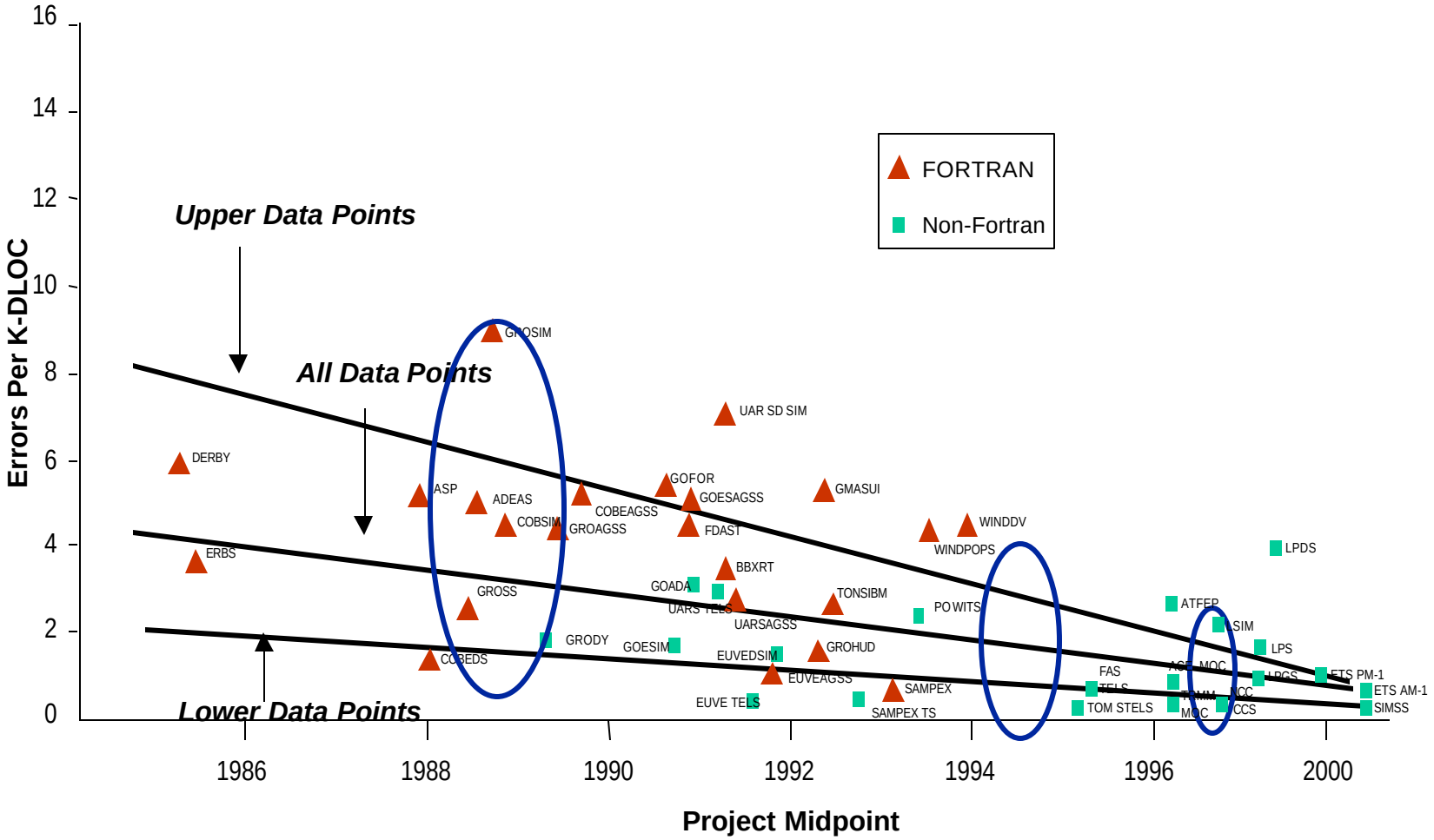


Consistency in Performance

2

- Deliverable products adhere to defined standard of form and format
  - Organization process defines process for end-items
    - ‘Most’ products (as opposed to ‘some’ or ‘many’) adhere to the standard of the organization
  - Internal consistency checks active (e.g. PAC, Audits)
- Mature processes have enabled more accurate estimation and implementation (more consistent)
  - Similar projects yield more consistent results
  - Planning, tracking, reporting lead to similar performance for similar tasks
- Long term product data verifies decreasing variances in product attributes (costing, defect rates, estimation accuracy)

Error rates for similar class of projects
(Variances Show Significant Decrease)

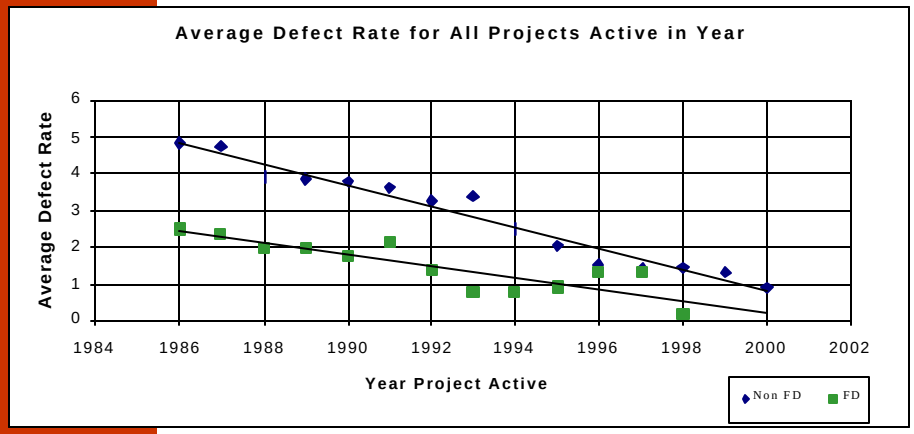


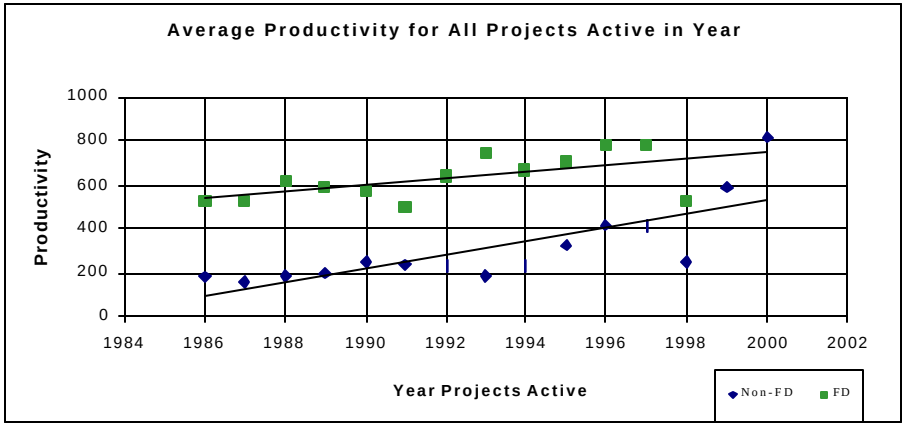
- Error models are well established; range of variation (indicated by the upper and lower lines) has narrowed, allowing managers to better manage quality
- Average error rate to has decreased by 75% since 1990

Sustained Improvements in Product Quality

3

- Average defect rates were cut by 50% in 5 years
- Productivity has shown consistent 6% yearly improvement during time of focused process improvement initiatives
  - Even though defect rate was the goal for improvement
  - Although several studies have indicated correlation between process maturity and decreased cost, CSC data has not been able to confirm results
  - Trends are observed over period of years
  - Isolated projects may indicate worsening trends





Visibility Into Issues, Risks, Performance

4

- Evidence of client input driving process execution
  - setting goals, tracking progress, reporting
- No surprises
  - SEAS cut ‘Red-Flag’ projects by 3 to 1 in 5 years.
    - Projects outside 10% limit of cost/schedule:
      - 17% in 1995 vs. 5.5% in 2000
- Planning and tracking aids exist and are used
  - e.g. Earned Value
- Risk, issues, assumptions continually visible
- Monitoring of adherence to processes ongoing
  - Audits/ management reviews
- Mutual trust encourages open communication
  - No hidden issues

High Level of Project Control

5

- Ability to respond to change
  - Drastic environmental change on ‘SEAS’ to SETS (sustained same, mature processes)
- What-if
  - Models and ‘cause-effect’ evidence facilitates ability to respond to alternative requirements/ analyze alternatives
  - Test models (e.g. 30% fail rate) adopted and applied to guide integration and delivery
- Issues/problems addressed with well-founded trade-offs
  - Awareness of impacts, alternatives
- Provide alternative solutions
- PCO ability to produce reliable performance data and projections

Summary: What the Client Should Expect

- Established processes that are defined, controlled, deployed and used.
- Models of performance
  - Measurements for costing, defects, life-cycle characteristics
- Management structure that supports awareness and application of process
- Ability to produce consistent planning information
- Ability to meet commitments
  - deliver what is planned in time-frame estimated
- Ability to respond to change
- Awareness of where the project/task is going and how much effort it will take to get there.
- Clear description of roles/responsibilities

Definitions for Performance Information

- **Size** – Amount of delivered source instructions (DSI). Categories are new DSI and reused DSI (COTS is also tracked)
- **Weighted DSI** – Total new DSI plus 25 % of total reused DSI
- **Effort** – Staff months spent from project start (start of s/w specs) to delivery to operations; all activities (managers, developers, testers, QA, CM) and all phases (requirements, design, code, and test) included.
- **Defects** – Number of errors found by independent testers before delivery that require a change to the executable code; defects do not include unit test or errors in documentation
- **Productivity** – Weighted DSI per staff month for a project
- **Cycle time** – Number of calendar weeks from project start to delivery (normalized by size)
- **Effort variance** – difference between actual total effort and estimated total effort (absolute value) divided by estimated total effort

References

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